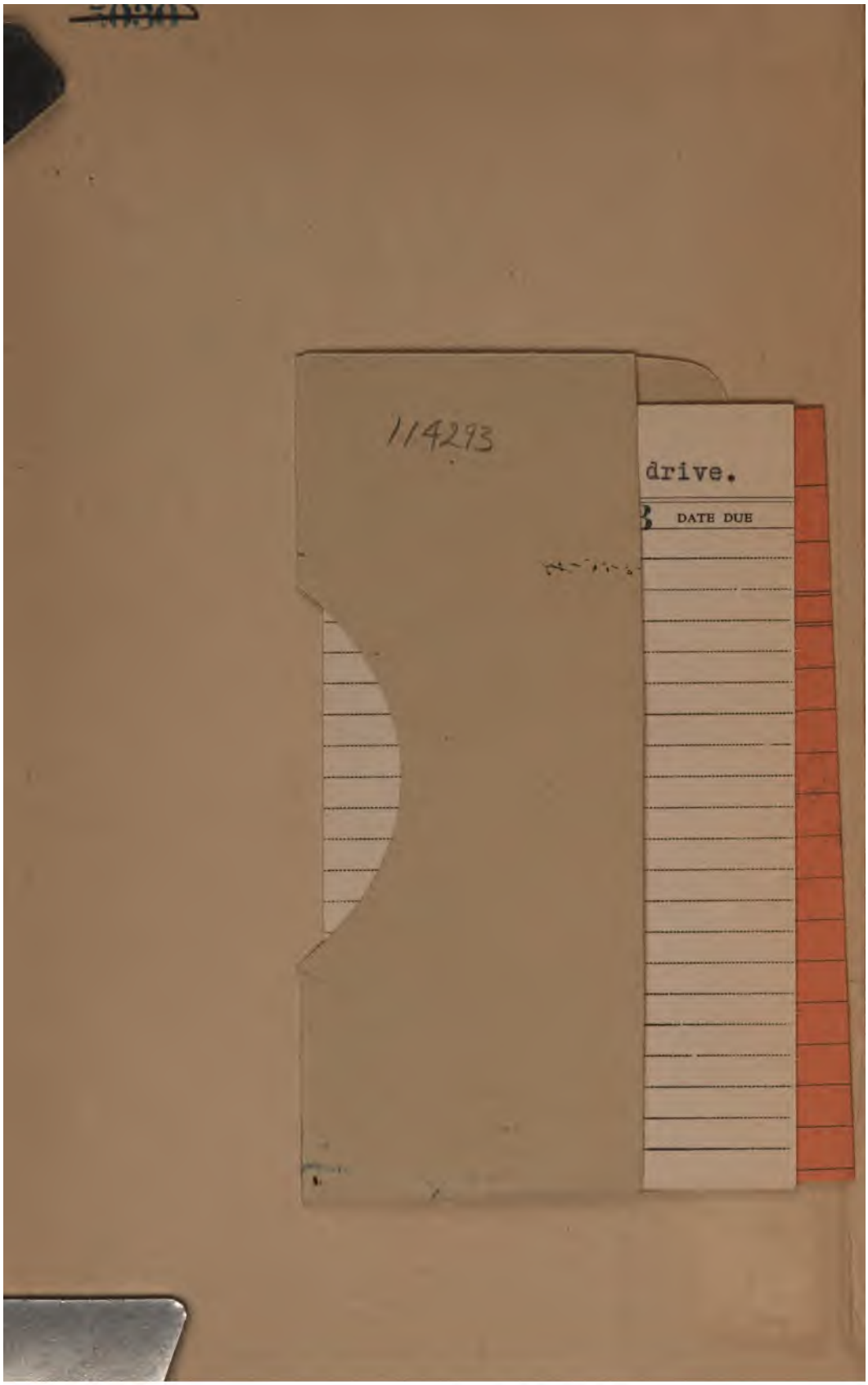
THE KINETIC DRIVE

GEORGE W. CRILE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THE KINETIC DRIVE

ITS PHENOMENA AND CONTROL

BY

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PREFATORY NOTE

THIS lecture is in effect an epitome of a monograph in preparation which will offer the complete experimental evidence upon which these themes and postulates are founded.

In that volume acknowledgment will be made of the valuable aid given by all who have collaborated with me throughout these researches, and in the bibliographic lists published therein will be found references to the literature which has been studied in this connection.

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CLEVELAND, OHIO.

May, 1916.

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I. INTRODUCTION

THE species of animal now dominating the earth more completely than any other is at this moment in a state of abnormal activity. The back-wash of the European War is seen in the quickened pulse everywhere, even in this land. Not only in war but in peace also the complicated machinery of civilization created by man often drives him to his own destruction. Nowhere is this industrial and commercial driving more intense than in this city. It has occurred to me, therefore, that it might be interesting to attempt an analysis of the mechanism by which this speeding is accomplished, and relate it to the speeding which is due to other stimuli, such as infections, auto-intoxication, physical injury, etc. Since the process of speeding is identical with that of the transformation of potential into kinetic energy, the state of increased energy transformation might fittingly be called the *kinetic drive.* To facilitate discussion I shall assume an unwarranted attitude of dogmatism which may be evaluated at leisure.

II. THE KINETIC MECHANISM

Man is a mechanism—an automaton—whose primary work is the transformation of energy by means of a system of organs especially adapted to this end. There is stored in these organs during sleep the energy which during con-

FIG. 1.—HISTOLOGIC CHANGES PRODUCED IN THE BRAIN BY PHYSICAL EXERTION, INFECTION, AND SKATOL (AUTO-INTOXICATION). (From photomicrographs × 310.)

A, Section of normal cerebellum of a cat. B, Section of cerebellum of a cat which had been subjected to extreme and prolonged physical exertion. C, Section of cerebellum of a cat after streptococcal infection. D, Section of cerebellum of a cat which had received repeated injections of skatol.

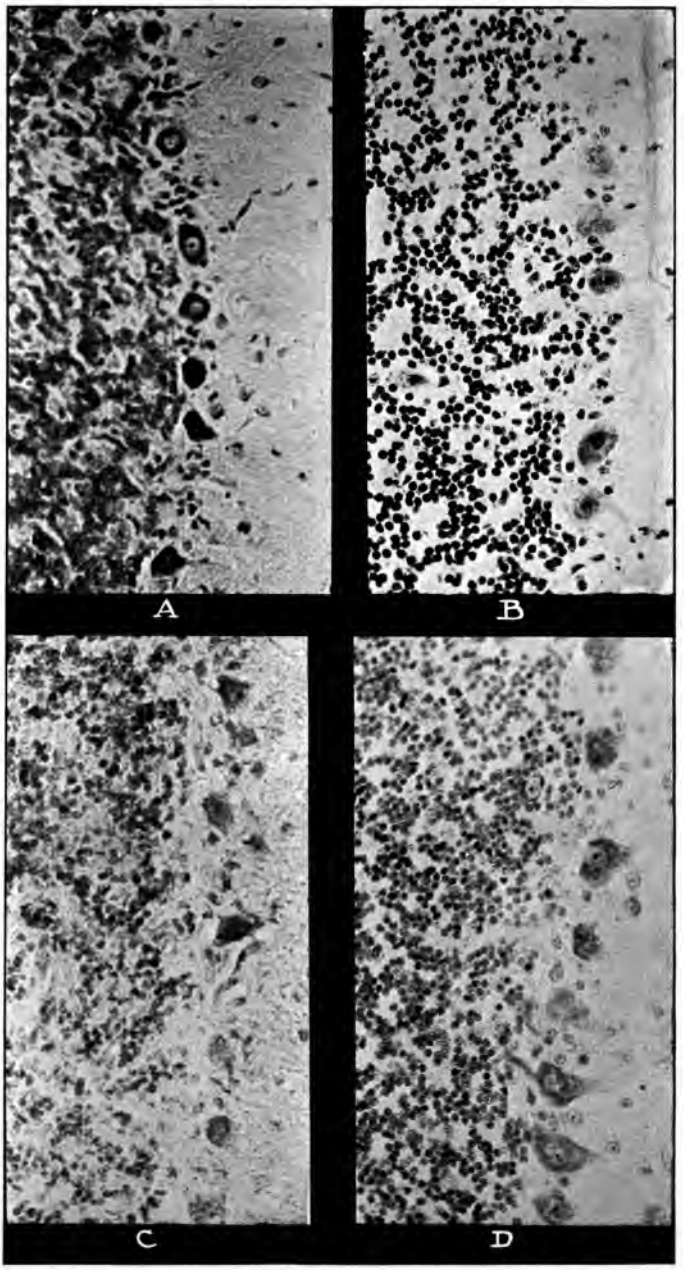


FIG. 1.

FIG. 2.—HISTOLOGIC CHANGES PRODUCED IN THE ADRENALS BY PHYSICAL EXERTION, INFECTION, AND SKATOL (AUTO-INTOXICATION). (From photomicrographs × 1640.)

A, Section of normal adrenal of a cat. B, Section of adrenal of a cat which had been subjected to extreme and prolonged physical exertion. C, Section of adrenal of a cat after streptococcal infection. D, Section of adrenal of a cat which had received repeated injections of skatol.

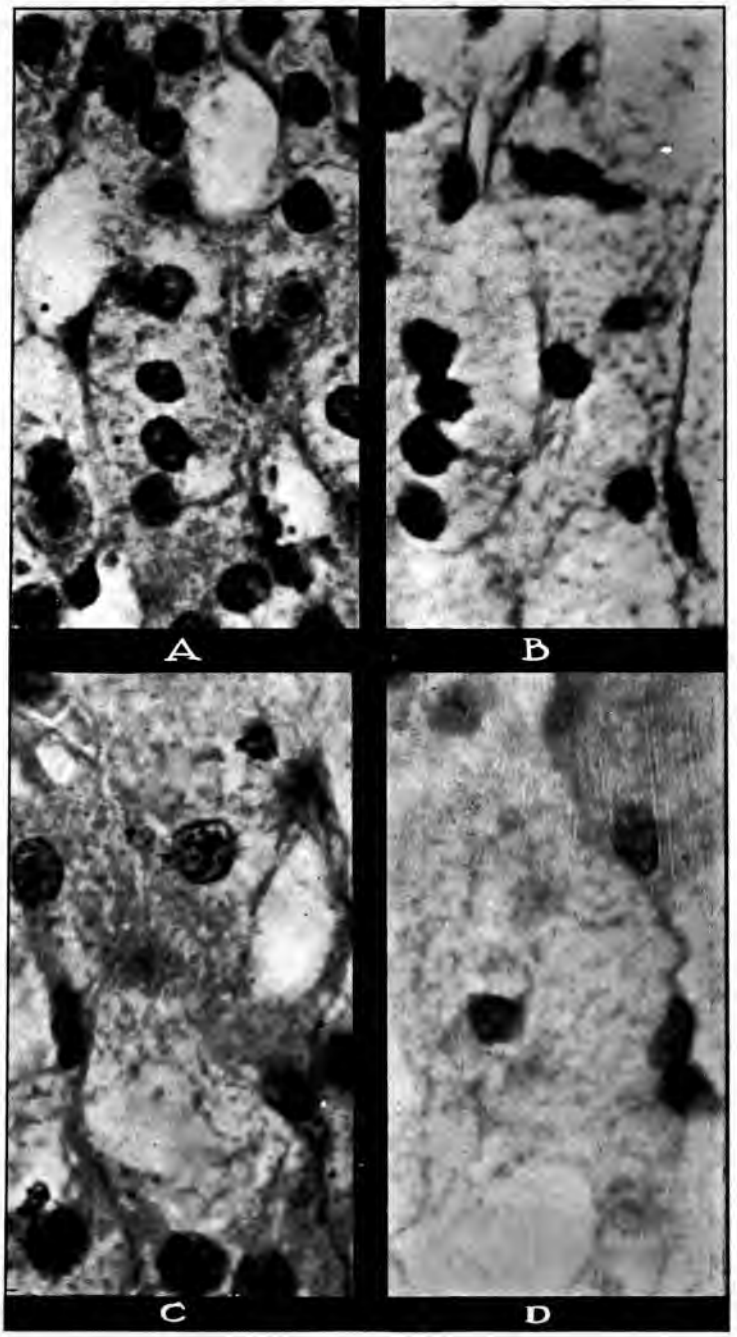
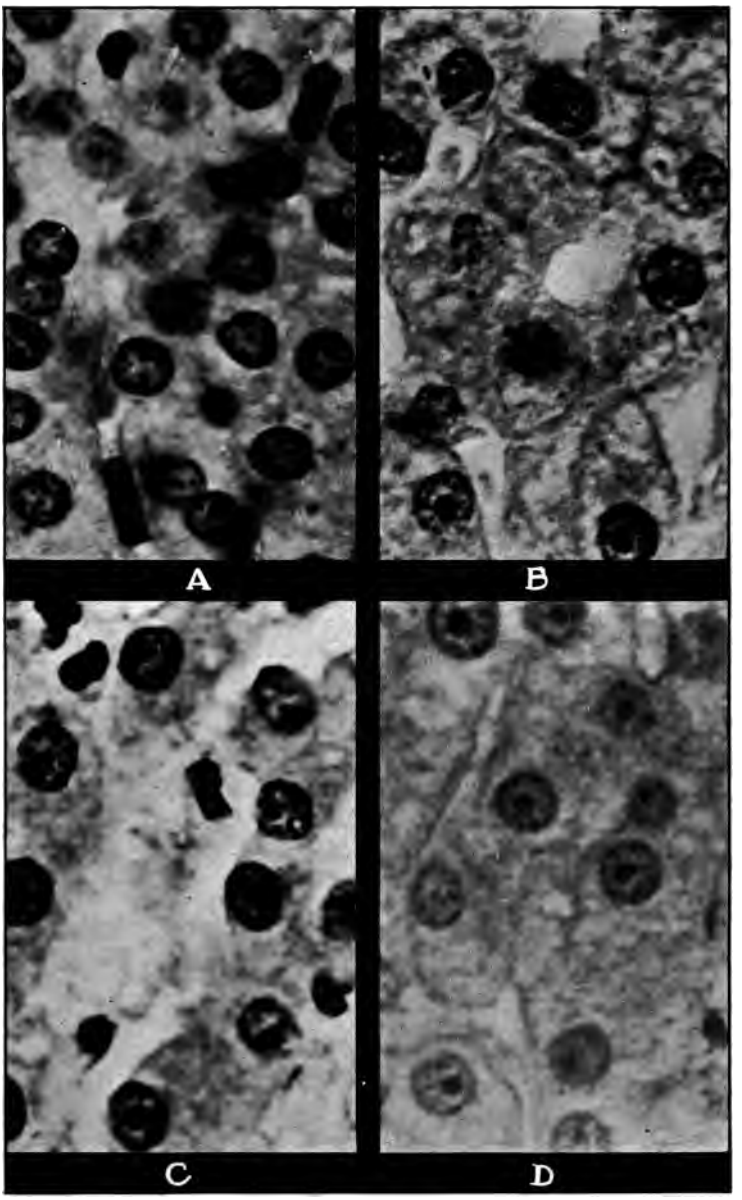


FIG. 2.

FIG. 3.—HISTOLOGIC CHANGES PRODUCED IN THE LIVER BY EXTREME PHYSICAL EXERTION, INFECTION, AND SKATOL (AUTO-INTOXICATION). (From photomicrographs × 1640.)

A, Section of normal liver of a cat. B, Section of liver of a cat which had been subjected to extreme and prolonged physical exertion. C, Section of liver of a cat after streptococcal infection. D, Section of liver of a cat which had received repeated injections of skatol.



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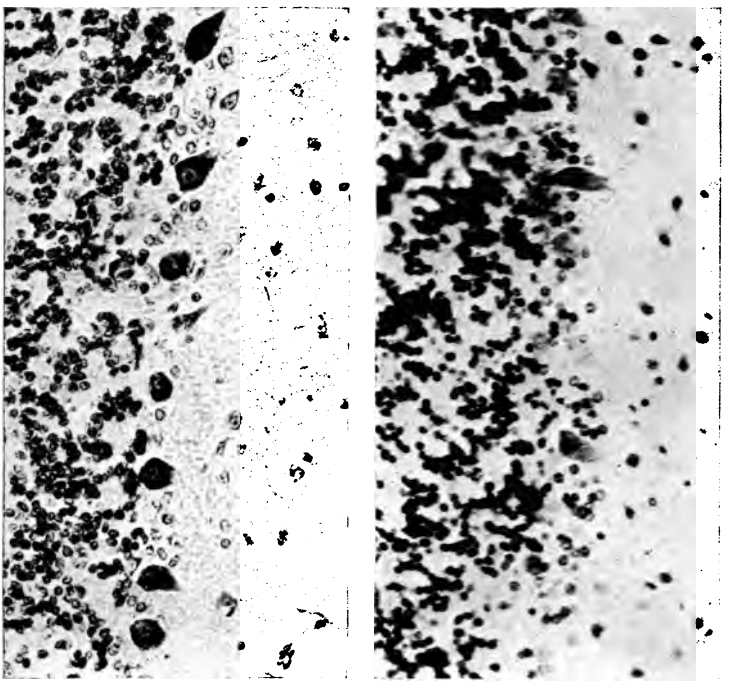


A
Section of normal cerebellum of cat.

B
Section of cerebellum of pregnant cat.

FIG. 4.—EFFECT OF PREGNANCY ON THE BRAIN-CELLS OF A CAT. (From photomicrographs × 310.)

The effect of the long activation of pregnancy is well illustrated by the generally disorganized appearance of the Purkinje cells in B.

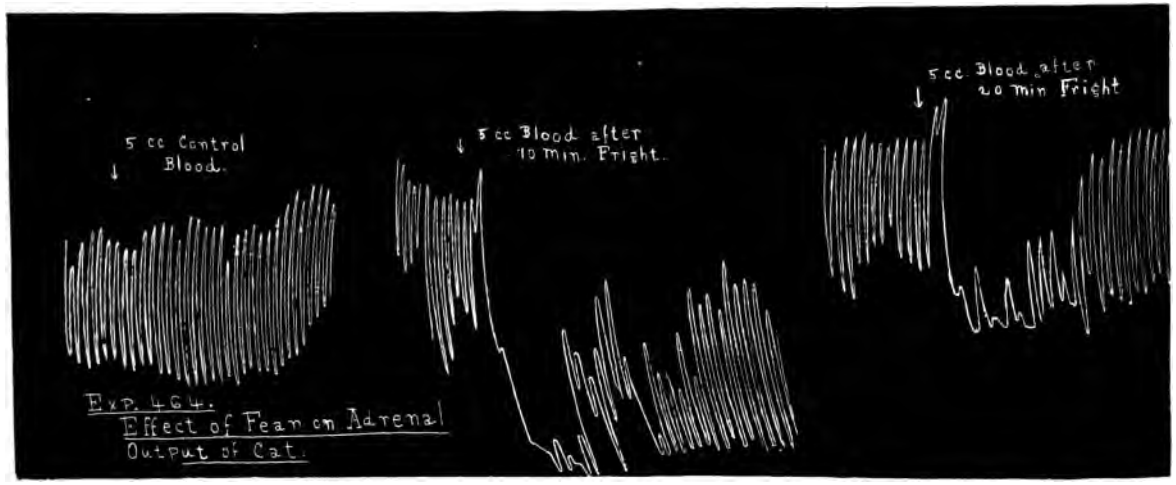


FIG. 5.—TRACING SHOWING EFFECT OF FEAR ON THE ADRENAL OUTPUT OF A CAT. (Cannon Test.)

The first tracing (A) was made by the contractions of intestinal muscle in blood from a normal cat. The contractions of the intestinal muscle were inhibited when the normal blood was replaced by blood from the same animal after it had been frightened. This inhibition is evidence of increased adrenin in the blood-stream, more adrenin apparently being produced in the early stages of fright (B) than in the later stages (C).

sciousness, in response to environmental contacts with distance, contact, or chemical ceptors, is transformed into muscular action, into heat, or into the representations of muscular action, such as emotional or "mental processes."

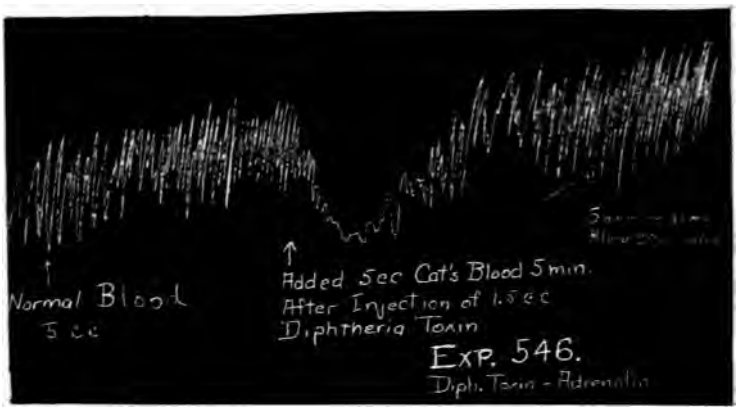
The impulse or driving force which causes the transformation of energy within the organism is supplied by certain parts of the brain, and in the brain is found also the mechanism which makes the final manifestation of the transformed energy specific to the environmental contact which initiated the driving.

The initiators of the kinetic drive may be roughly classed as *contact ceptor stimuli*—physical injury, heat, cold, etc.; *distance ceptor stimuli*—written and spoken language, sight, smell, etc., and *chemical ceptor stimuli*—infection, autointoxication, pregnancy, excessive food, poisons, etc. Whether any one of these stimuli acts singly or in combination with others, the end-effects are identical. The effects of any one, therefore, may be studied as typifying all the rest.

The organs which from moment to moment vary and control, accelerate or retard the driving force of the brain are the adrenals; the pacemaker of the kinetic system is the thyroid; and the final act of adaptive energy transformation is performed by the muscles.

The primary process within the brain by means of which its driving force is created and sustained is oxidation. Oxygen is supplied by the lungs. If the blood be acid, oxygen cannot be carried by the hemoglobin. Energy transformation depends, therefore, upon the maintenance of the alkalinity of the blood. Since the transformation of energy in the body is always accompanied by the formation of acid by-products, the continuance of the process of energy transformation demands a mechanism or mechanisms

by means of which the acid by-products can be neutralized and eliminated. These needs are met mainly by the liver, the kidneys, and the lungs. The acid by-products of energy transformation are, to a large extent, broken down in the liver into simple compounds which are harmless to the kidneys, by which these soluble end-products are eliminated; while the gaseous end-products are eliminated by the lungs.



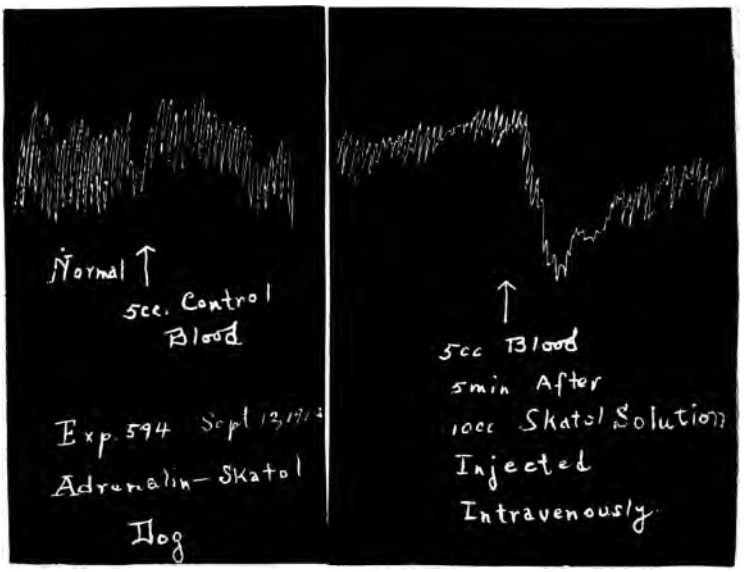
A B C

FIG. 6.—TRACING SHOWING THE EFFECT OF DIPHTHERIA TOXIN ON ADRENAL OUTPUT OF A CAT. (Cannon Test.)

The first tracing (A) was made by the contractions of intestinal muscle beating in blood from a normal cat. These contractions were inhibited almost entirely by the substitution of blood from the same cat after the injection of diphtheria toxin (B). After twenty minutes the increased adrenin evidenced by B was oxidized and the intestinal muscle resumed its contractions as in normal blood.

If this system of organs which we postulate is primarily adapted for the transformation of energy, acts as a *unit*, and is restored only during sleep, then every excessive excitant of muscular action or of heat production between periods of sleep—such as prolonged consciousness (insomnia), muscular action, emotion, mental exertion, infection, foreign proteins, even pregnancy, etc.—should cause identical changes in the

histologic structure and the function of each organ concerned in the transformation of energy or in the neutralization and elimination of the resultant acid by-products; and, in addition, intense and short as well as long-continued activation by any of these agents should cause also identical



A B

FIG. 7.—TRACING SHOWING EFFECT OF SKATOL ON THE ADRENAL OUTPUT OF A DOG. (Cannon Test.)

The first tracing (A) was made by the contractions of intestinal muscle in blood from a normal dog. The second tracing (B) shows the partial inhibition of the contractions produced by the substitution of blood after the injection of skatol, evidencing the presence in the blood of an increased amount of adrenin.

acute and chronic diseases. In other words, insomnia, intense emotion, extreme exertion, infection, foreign proteins, pregnancy, etc., should cause histologic changes in the brain, the adrenals, and the liver (Figs. 1–4); an increased output of adrenin (Figs. 5–8); hyperplasia of the thyroid and a

change in its iodin content, and changes in the glycogen content of the muscles and of the liver.

If the foregoing be true, then it would follow that each of these activators would cause increased acid by-products. Therefore exertion, infection, emotion, mental activity (intensified consciousness), foreign proteins, or pregnancy should produce certain identical clinical phenomena.

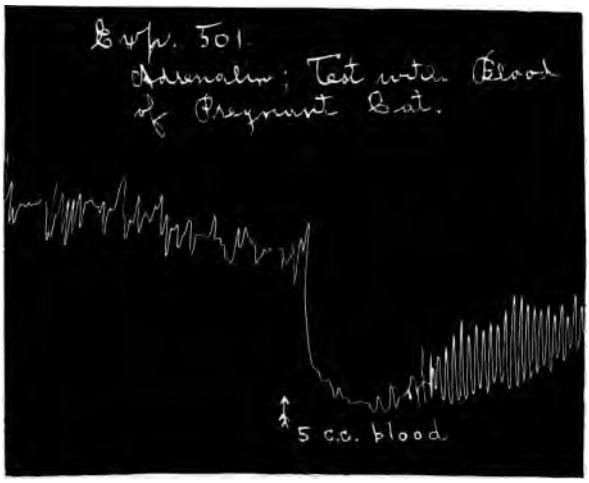


FIG. 8.—TRACING SHOWING EFFECT OF PREGNANCY ON THE ADRENAL OUTPUT OF A CAT. (Cannon Test.)

That the adrenal glands are activated during pregnancy is demonstrated by this sharp inhibition of the contractions of intestinal muscle when the blood of a pregnant cat is substituted for normal blood.

First of all, we know that each of these activators causes increased respiration, increase in the frequency and force of the heart-beat, thirst, excitability, perspiration, increased acidity of the urine, and identical manifestations of fatigue and exhaustion. If the adrenals determine the driving force of the brain from moment to moment, and if each activation of the *Kinetic System* causes an increased

output of adrenin, then it would follow that adrenin alone would produce the basic phenomena caused by any excitant of energy transformation—such as exertion, injury, infection, emotion, pregnancy, etc.—and would produce identical histologic lesions; and it does. In addition, adrenin given over a long period of time causes myocarditis, glycosuria, albuminuria, fatigue, and, in addition, many symptoms of cardiovascular disease and of cardiorenal disease.

III. FUNCTIONS OF THE ADRENALS AND OF THE THYROID IN THE KINETIC DRIVE

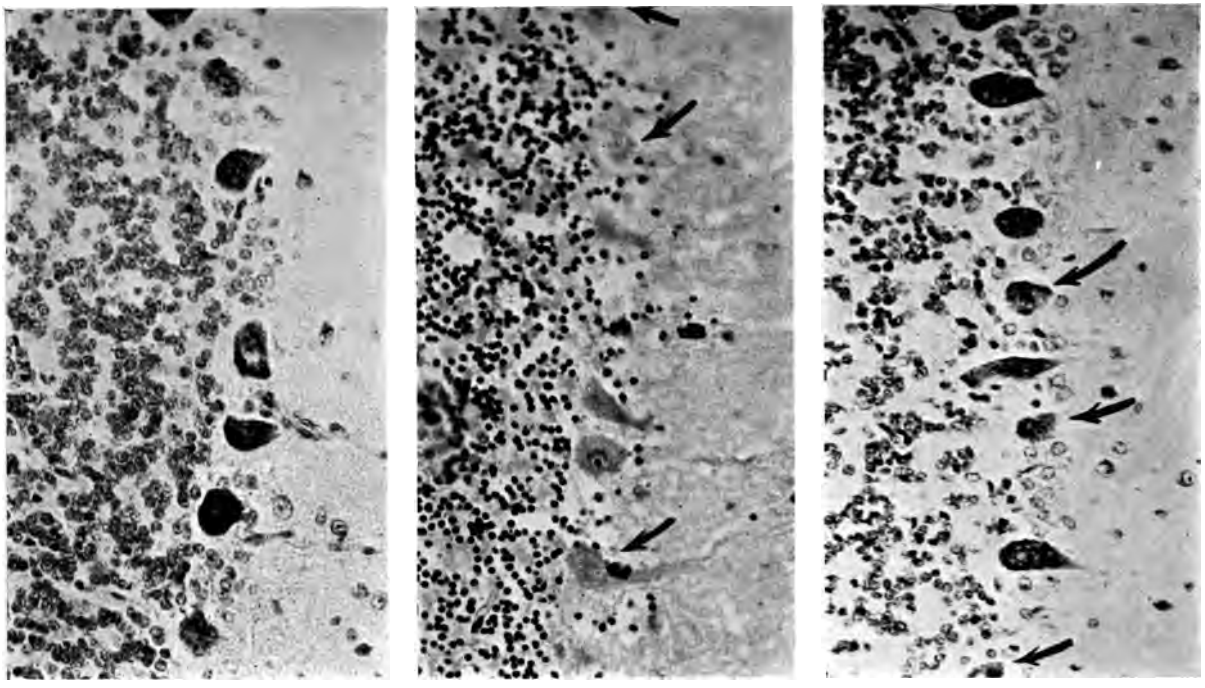
If adrenin causes phenomena identical with those produced by emotion, exertion, infection, etc., and if, *vice versa*, emotion, infection, exertion, etc., each causes an increased output of adrenin, then we may infer that it is through the increased mobilization of adrenin that increased energy transformation is accomplished by each of these activators. Again, if this be the rôle of adrenin, we should find that in a state of adrenal deficiency the manifestation of energy transformation would be diminished. And we find that this is true, for, after double adrenalectomy, there is a decreasing and finally a total loss of muscular power and of heat production (Fig. 9).

If the nerve-supply of the adrenals be divided and then an adequate adrenal stimulus applied, the output of adrenin is not increased. If the nerves are intact, and a large dose of morphin be previously given, the application of an adequate adrenal stimulus causes no increased output of adrenin.

We therefore conclude that the brain controls the transformation of energy by first driving the adrenals, thus mobilizing adrenin which is carried to the brain in the bloodstream. The result of the chemical combination of oxygen,

adrenin, and brain-cell substance appears to be the production of energy impulses, these impulses being probably identical with electricity (Crehore and Williams). The electromotive force thus supposed to be fabricated in the brain is transmitted to the muscles, where the energy is finally transformed into heat, running, fighting, etc. Since the adrenals hold but a limited supply of adrenin, one would expect to find in the body some organ whose function is the secretion in abundant quantity of a substance by which the efficiency of adrenin is increased. The belief that this function is performed by thyroid secretion is strengthened by the researches of Osterhaut, who found that iodin causes an increased permeability of living vegetable tissue to the passage of electricity. The activity of thyroid secretion is directly proportional to the amount of iodin it contains, and we know that excessive doses of iodin alone cause all the phenomena of emotion, exertion; and inversely, that emotion, infection, exertion, etc., cause changes in the iodin content of the thyroid (Fig. 10). If in the midst of iodism double adrenalectomy be performed, the phenomena of iodism should be diminished.

In this interrelation of the brain, the thyroid, and the adrenals we have what perhaps is the master key to the automatic action of the body; that is, through the special senses environmental stimuli reach the brain and cause it to liberate energy, which in turn directly or indirectly activates certain other organs and tissues, among which are the thyroid and the adrenals. The increased output of thyreoiodin, by facilitating the transmission of electric currents through semi-permeable membranes, increases the passage of nerve-impulses and sets the pace for energy conversion. In consequence, the adrenals are driven to increased activity, and the increased adrenin in turn excites the brain to still greater activity, the



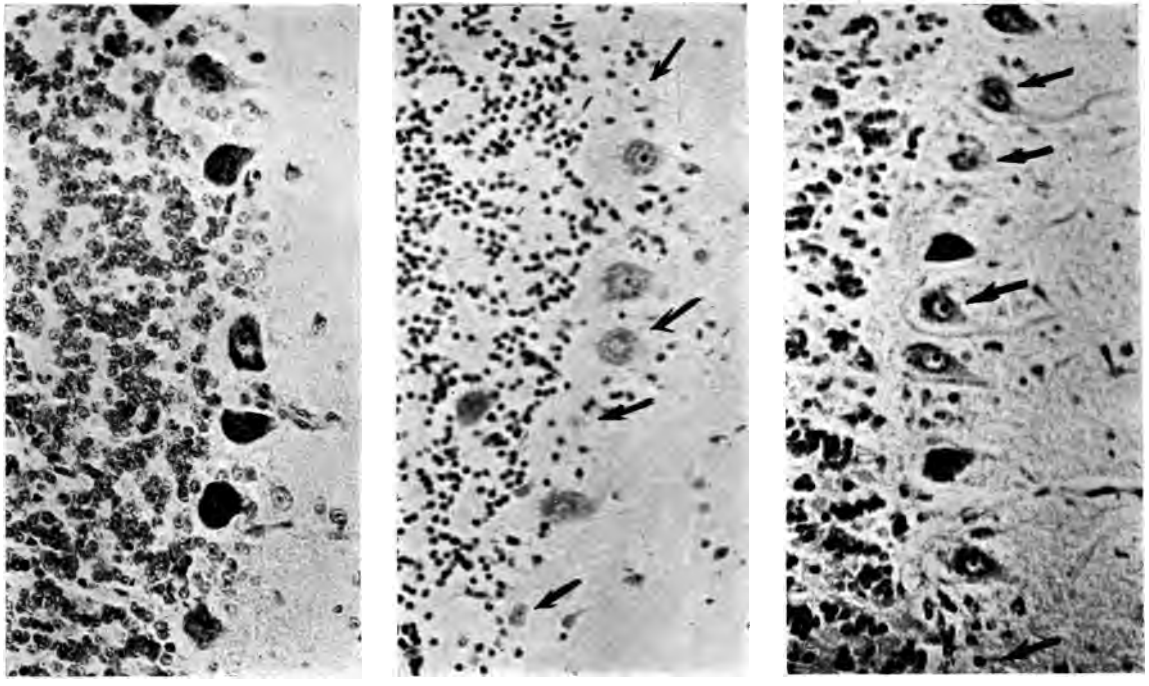
A
Section of normal cerebellum of a dog.

B
Section of cerebellum of dog after adrenalectomy.

C
Section of cerebellum of dog after repeated injections of adrenin.

FIG. 9.—COMPARATIVE EFFECTS OF EXCISION OF THE ADRENAL GLANDS AND OF EXCESSIVE ADMINISTRATION OF ADRENIN ON THE BRAIN-CELLS OF DOGS. (From photomicrographs × 310.)

The disastrous effect of withdrawing adrenin from the kinetic system is apparent in B in the extensive loss of chromatic material in all the cells, the cellular disintegration of many, and the almost complete degeneration of some cells. The effect of a continuous activation of the system by the excessive administration of adrenin is strikingly shown in C by the large number of hyperchromatic cells, together with evidences of exhaustion and disintegration in some cells. These effects are similar in kind and analogous to the effects produced by withdrawing thyroid secretion or by administering excessive doses of thyroid extract.



A
Section of normal cerebellum of dog.

B
Section of cerebellum of dog after thyroidectomy.

C
Section of cerebellum of dog after continued feeding with thyroid extract.

FIG. 10.—COMPARATIVE EFFECTS OF EXCISION OF THE THYROID AND EXCESSIVE FEEDING WITH THYROID EXTRACT ON THE BRAIN-CELLS OF DOGS. (From photomicrographs × 310.)

The harmful effects of withdrawing thyroid secretion from the organism is shown in B in the high percentage of degenerated cells, the loss of chromatic material, and complete disintegration of many cells. The effect of a continuous activation of the system by excessive feeding with thyroid secretion is evidenced in C by degenerated cells. The cells in both B and C present a marked contrast to the uniform stainability and clearly defined outlines of the cells in A.

FIG. 11.—THE EFFECTS OF EXTREME ACTIVATION ON THE BRAIN, ADRENALS, AND LIVER OF A SOLDIER WHO HAD SUFFERED FROM HUNGER, THIRST, AND LOSS OF SLEEP; HAD MADE THE EXTRAORDINARY FORCED MARCH OF 180 MILES FROM MONS TO THE MARNE; IN THE MIDST OF THAT GREAT BATTLE WAS WOUNDED BY THE EXPLOSION OF A SHELL; LAY FOR HOURS WAITING FOR HELP, AND DIED FROM EXHAUSTION SOON AFTER REACHING THE AMBULANCE. (A and D from photomicrographs × 310; B, C, E, and F from photomicrographs × 1640.)

A, Section of normal cerebellum; B, section of normal adrenal; C, section of normal liver; D, section of cerebellum of soldier described above; E, section of adrenal of soldier described above; F, section of liver of soldier described above.

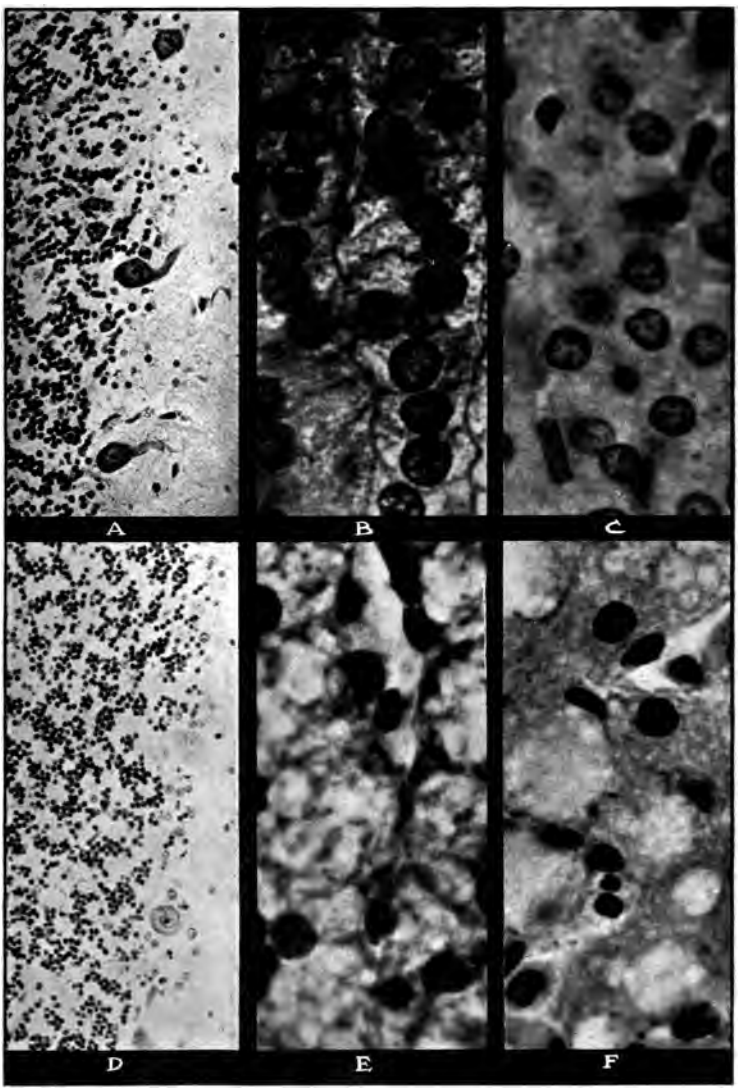


FIG. 11.

results of which are equivalent to increased work of the sympathetic nervous system. These results are principally the following—increased heart-beat, increased respiration, raised blood-pressure, increased sweating, thirst, the transfer of much of the blood from the splanchnic area to the surface, increased output of glycogen, increased power of the muscles to metabolize glycogen, increased acid excretion in the urine, certain histologic and chemical changes, and exhaustion.

The phenomena of the kinetic drive in animals and in man are, therefore, essentially the phenomena of the kinetic drive of a locomotive. The locomotive consumes carbon in the form of coal; man consumes carbon in the form of glycogen. The locomotive produces heat and motion; man produces heat and motion. The locomotive produces gaseous and solid acid by-products—so does man. If the exchange of gases in the firebox of a locomotive is stopped, energy transformation ceases, the locomotive dies; if the exchange of gases in man is suspended, man ceases to transform energy—man dies.

Never before has there been such an opportunity for studying the behavior of the human mechanism under the strongest physical and psychic stress as in warring Europe today. There observations of the injured, of soldiers in the field, of prisoners and of refugees gave me an opportunity for studying the human kinetic drive on a vast field. The photomicrographs show the effect upon the brain, the adrenals, and the liver of some of the kinetic stimuli to which these men had been subjected (Fig. 11).

IV. CONTROL OF THE KINETIC DRIVE

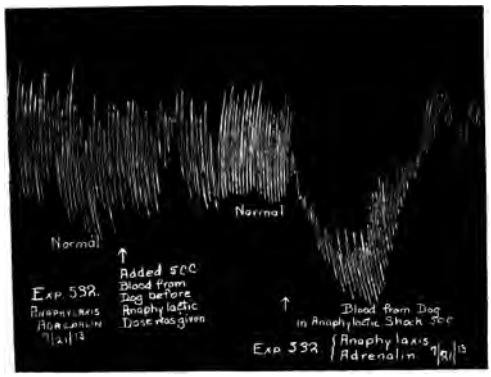
Turning from the phenomena of the kinetic drive to methods of control, we find first that morphin controls the rate of energy transformation in response to any stimulus.

Whatever the activation, whether infection, emotion, injury, or Graves' disease, morphin measurably controls the outward phenomena, such as the pulse-rate, respiratory exchange, sweating, thirst, restlessness, acid excretion, fever, muscular action, and pain.

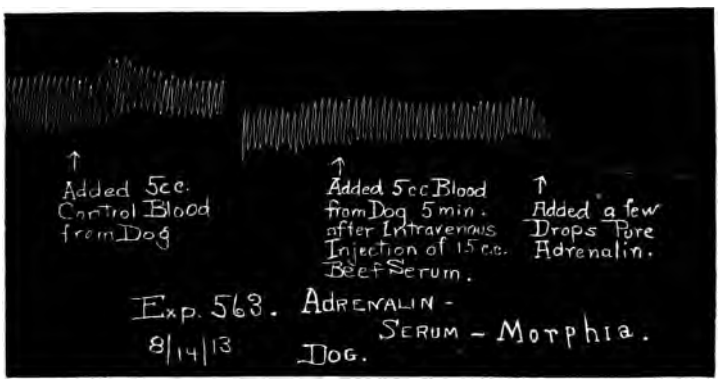
The value of opium in infections and in pain is one of the foundation stones of medicine. And here I must pause for a moment to pay tribute to a talented New York physician, Alonzo Clark, who on empyric grounds made a daring innovation in the opium treatment of peritonitis.

Even today we must concede that next to surgical treatment the administration of opium is the most efficient treatment for peritonitis. Guided by researches made in my laboratory, in collaboration with my associates, I have combined the administration of opium with surgical treatment in those cases of peritonitis only in which the kinetic drive threatens to kill the victim. In such cases a quick anociated operation under nitrous oxid, Fowler's position, huge hot packs, saline infusions, sodium bicarbonate, and glucose plus the Alonzo Clark opium treatment for from twenty-four to forty-eight hours has given startlingly good results. Opium blocks the kinetic drive; draining relieves tension; water and alkalies control acidosis, and the patient gets well. Death from acute peritonitis from any cause has almost disappeared from the Lakeside Clinic. The amount of opium must be determined not by quantity, but by its effect on the drive—the respirations should be reduced to from 12 to 15 per minute. In severe cases there must be no therapeutic faint-heartedness.

The final test of any theory in medicine is in the crucible of the clinic. Our laboratory findings support not only the kinetic theory, but also the postulate that the kinetic drive may be largely controlled by the use of morphin, nitrous oxid,



A



B.

FIG. 12.—TRACING ILLUSTRATING PROTECTIVE EFFECT OF MORPHIN IN ANAPHYLACTIC SHOCK.

In A the adrenin which appears in the blood as a result of *anaphylaxis* inhibits the contractions of the intestinal muscle. Tracing B shows that the injection into a morphinized animal of beef-serum, which in the normal animal would have caused a strong anaphylactic reaction and a greatly increased output of adrenin, causes no increased output of adrenin as is evidenced by the contractions of intestinal muscle, as in normal blood. Since morphin acts directly upon the brain, this experiment evidences not only the protective effect of morphin, but also the dependence of the adrenal upon the brain for its activity.

and alkalies. In the laboratory we have found that morphin prevents the mobilization of adrenin (Fig. 12); that morphin and nitrous oxid block energy transformation and pre-

FIG. 13.—PROTECTIVE EFFECT OF MORPHIN AND OF NITROUS OXID ON THE BRAIN-CELLS OF DOGS WHICH HAD RECEIVED INJECTIONS OF DIPHTHERIA TOXIN. (From photomicrographs × 310.)

Compare the Purkinje cells in C and D with the disintegrated hypochromatic cells in B.

A
Section of normal cerebellum of a dog.

B
Section of cerebellum of a dog after injection of diphtheria toxin.

C
Section of cerebellum of a dog after injection of diphtheria toxin *plus* morphin.

D
Section of cerebellum of a dog after injection of diphtheria toxin and the continuous administration of nitrous oxid for four hours.

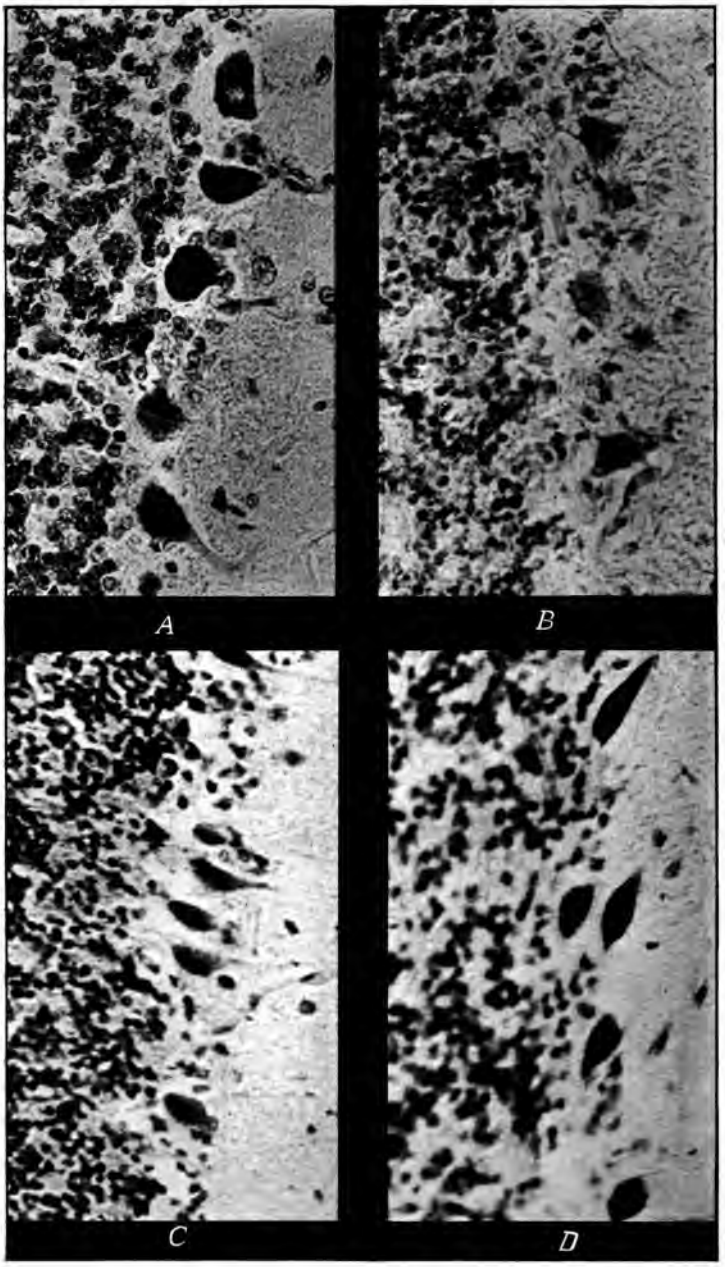


FIG. 13.

FIG. 14.—PROTECTIVE EFFECT OF MORPHIN AND OF NITROUS OXID ON THE ADRENALS OF DOGS WHICH HAD RECEIVED INJECTIONS OF DIPHTHERIA TOXIN. (From photomicrographs × 1640.)

Note the general disappearance of cytoplasm and nuclei in B and compare with the normal appearance of C and the conserved nuclei in D.

A
Section of normal adrenal of dog.

B
Section of adrenal of a dog after injection of diphtheria toxin.

C
Section of adrenal of a dog after injection of diphtheria toxin *plus* morphin.

D
Section of adrenal of a dog after injection of diphtheria toxin and the continuous administration of nitrous oxid for four hours.

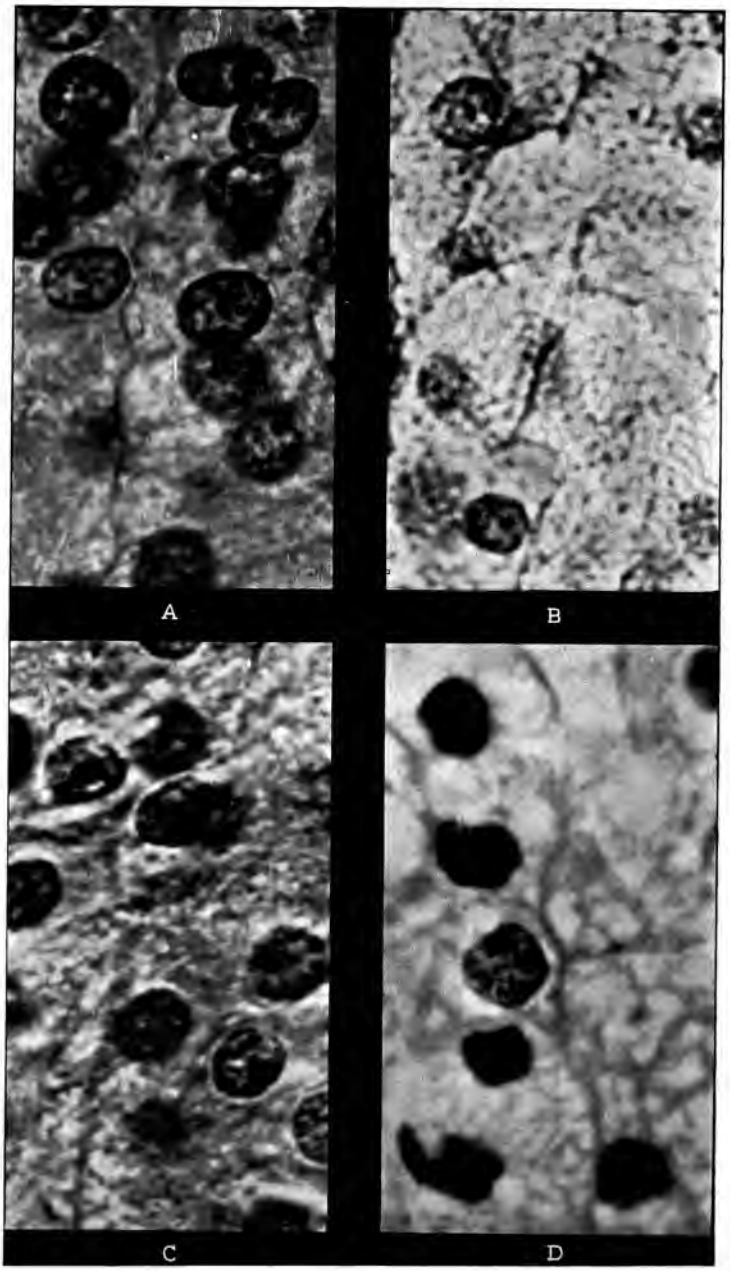


FIG. 14.

FIG. 15.—PROTECTIVE EFFECT OF MORPHIN AND OF NITROUS OXID ON THE LIVERS OF DOGS WHICH HAD RECEIVED INJECTIONS OF DIPHTHERIA TOXIN. (From photomicrographs × 1640.)

Note the vacuolation of B and compare with the conservation of nuclei and cytoplasm in C and D.

A
Section of normal liver of a dog.

B
Section of liver of a dog after injection of diphtheria toxin.

C
Section of liver of a dog after injection of diphtheria toxin plus morphin.

D
Section of liver of a dog after injection of diphtheria toxin and the continuous administration of nitrous oxid for four hours.

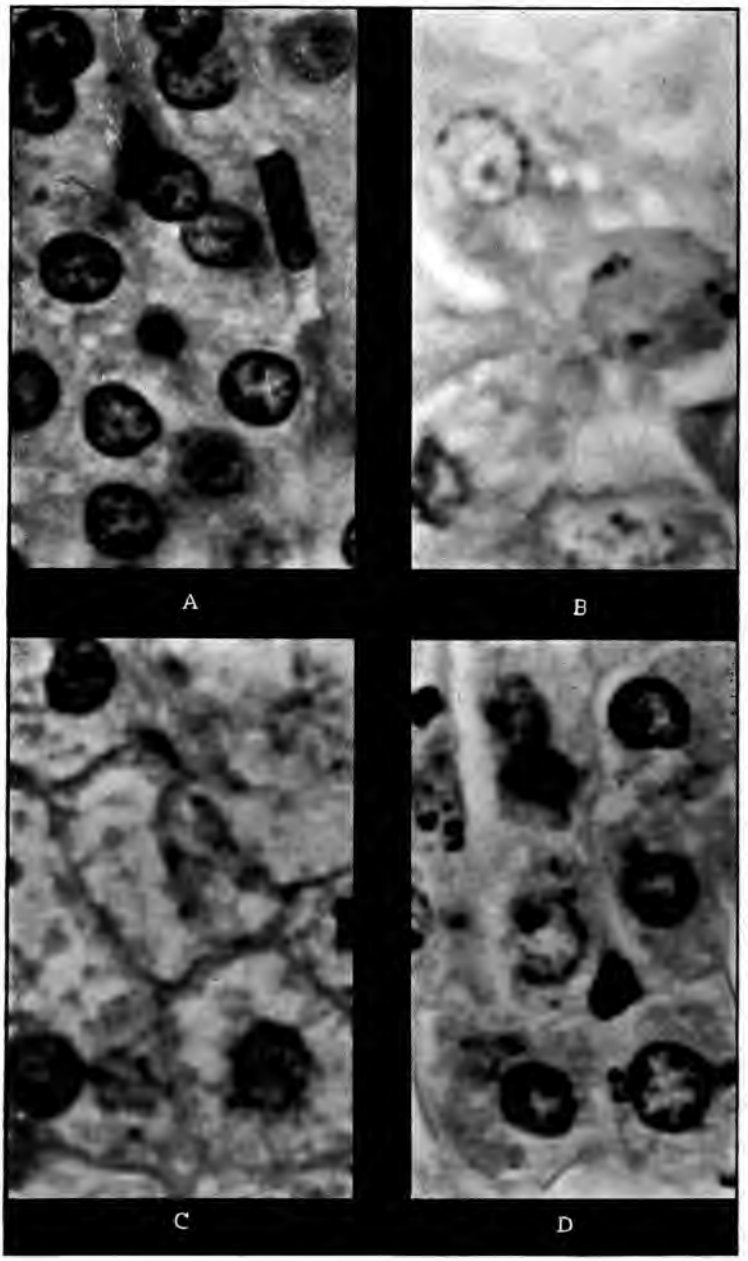
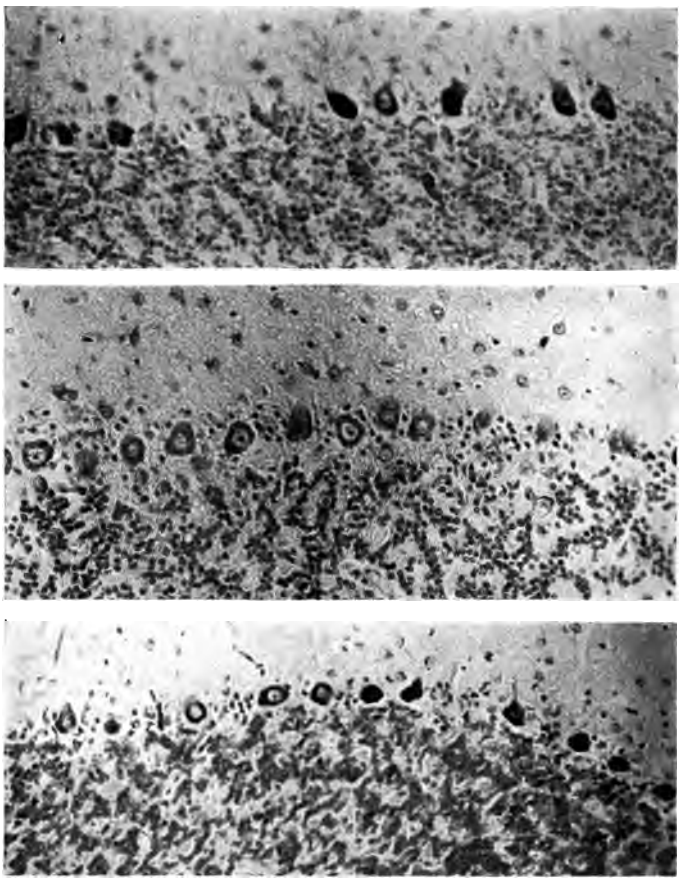


FIG. 15.



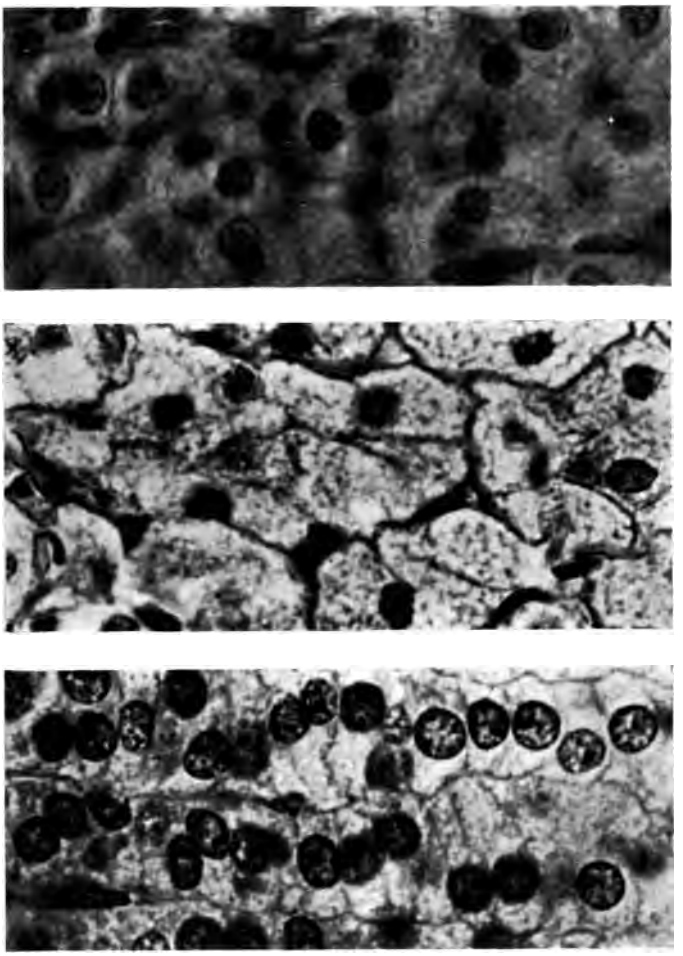
A
Section of normal cerebellum of cat.

B
Section of cerebellum of cat after injection of acid sodium phosphate.

C
Section of cerebellum of cat after injection of sodium bicarbonate.

FIG. 16.—THE COMPARATIVE EFFECTS OF AN ACID AND OF AN ALKALI ON THE BRAIN-CELLS OF CATS. (From photomicrographs × 310.)

Compare the Purkinje cells in the three sections, noting in C the conserving effect of the alkali as compared with the disorganizing effect of the acid in B.



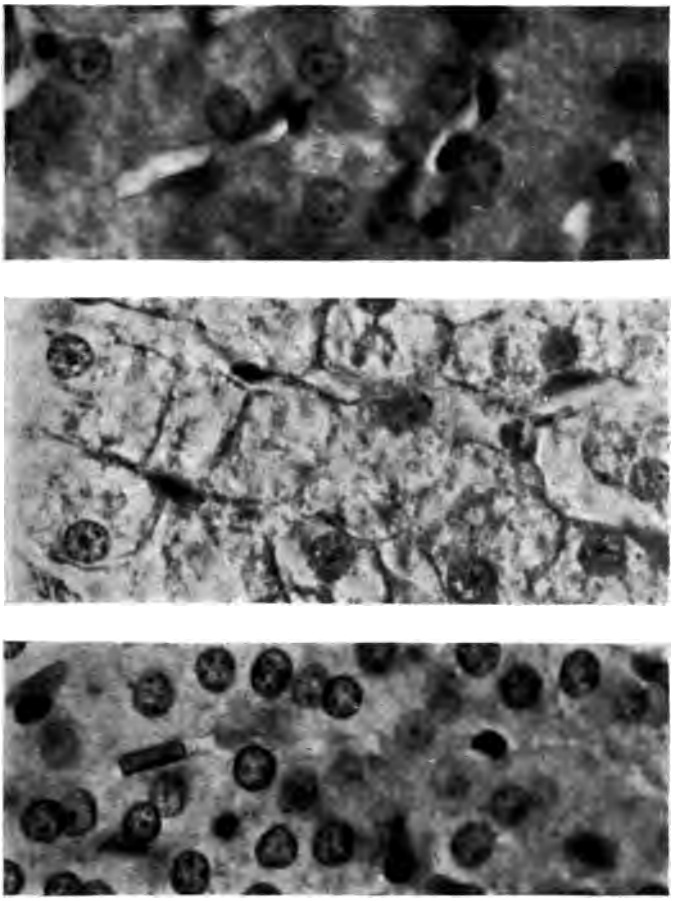
A
Section of normal adrenal of cat.

B
Section of adrenal of cat after injection of acid sodium phosphate.

C
Section of adrenal of cat after injection of sodium bicarbonate.

FIG. 17.—THE COMPARATIVE EFFECTS OF AN ACID AND OF AN ALKALI ON THE ADRENALS OF CATS. (From photomicrographs × 1640.)

Note the disappearance of cytoplasm in C and the eccentric and crenated nuclei as compared with the nearly normal appearance of C.



A
Section of normal liver of cat.

B
Section of liver of cat after injection of acid sodium phosphate

C
Section of liver of cat after injection of sodium bicarbonate.

FIG. 18.—THE COMPARATIVE EFFECTS OF AN ACID AND OF AN ALKALI ON THE LIVERS OF CATS. (From photomicrographs × 1640.)

Note the disappearance of cytoplasm and of nuclei and the vacuolated spaces in B as compared with the conservation of cell substance in C.

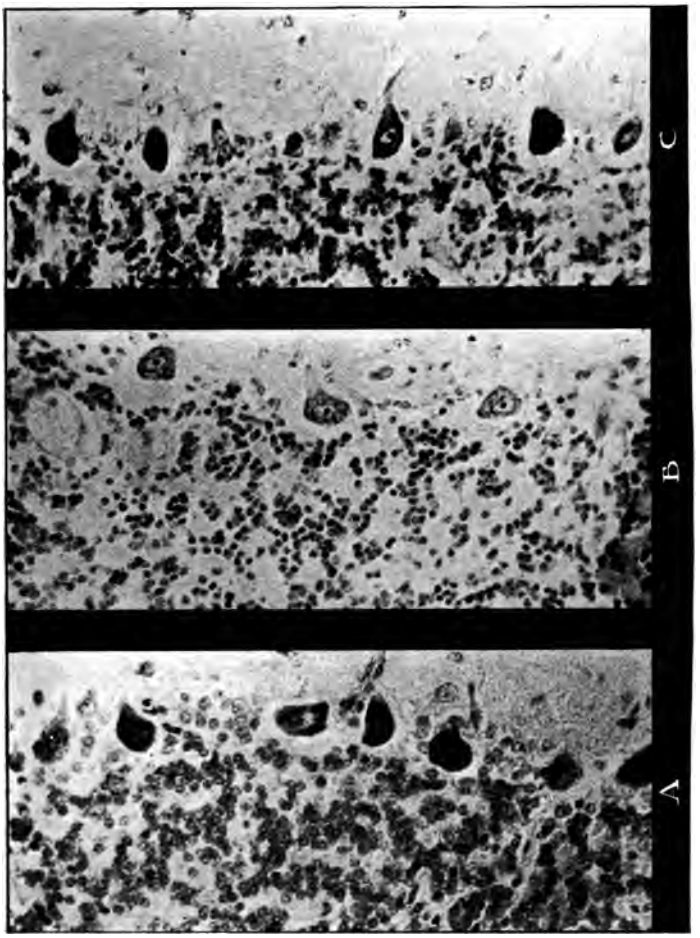


FIG. 19.—COMPARISON BETWEEN THE EFFECTS OF SURGICAL TRAUMA ON A NORMAL DOG AND ON A DOG WHOSE CORD HAD BEEN SEVERED. (From microphotographs × 310.)

A, Section of normal cerebellum of a dog; **B**, section of cerebellum of a dog which had received severe surgical trauma; C, section of cerebellum of a dog which received severe surgical trauma after the spinal cord had been severed.

vent the histologic changes wrought by physical injury, infection, and emotion (Figs. 13–15), and that alkalies counteract the effect of a kinetic drive by supplying the rapidly increasing deficiency of neutralizing bases (Figs. 16–18). These laboratory findings have been tested in Lakeside Hospital in a long series of operations on the stomach and the intestines, on the biliary tract, the pelvic organs, and the appendix; in clean cases and in cases complicated by the severest acute infections, with a resultant remarkable reduction in both morbidity and mortality.

The excessive energy transformation caused by physical injuries, such as blows, crushes, penetrations, surgical operations, etc., like that caused by infection, may be blocked by morphin and nitrous oxid and the effect minimized by alkalies and water, and, as in the infections, the dosage should be proportional to the intensity of the activation. In surgical operations the brain may be insulated, and in consequence its driving power prevented by local anesthesia of the surgical field, or by blocking the spinal cord or the nerve-trunks communicating with the field (Fig. 19). While it is safe to block the kinetic drive by morphin in cases of acute injury or of acute infection, it is unsafe to use opium to block the effects of intense emotion because of the danger of habit formation. The tendency to habit formation, however, is the strongest possible evidence of the power of morphin to control the kinetic drive. The emotional drive with its consequences, identical with the consequences of infection, exertion, or physical injury, is best met through training and education leading to a philosophy of life that insulates the individual against destructive psychic stimuli. Thus may the individual be anociated in the large clinic of life, just as through local anesthesia the patient is anociated against the drive of the surgeon's knife.

V. THE CHRONIC KINETIC DRIVE

Turning now from the individual *acutely* driven by injury, by infection, by emotion, let us consider the individual *chronically* driven by the stimuli of want, ambition, anger, jealousy, or grief; by infection, by pain, by auto-intoxication. In the *acute* kinetic drive the individual is endangered by death from exhaustion or from acid intoxication; whereas in the *chronic* drive the danger is that one or another of the overdriven organs or tissues may be permanently injured. In an acute drive simple and direct control is possible; in a chronic drive we may encounter the added difficulties of pathologic changes in one or more organs or tissues. We shall, therefore, discuss separately methods of control for those cases of chronic drive in which no organic change exists and for those in which organic changes do exist.

The common chronic drives are mental and muscular overwork, chronic infections, excessive diet, pregnancy; the emotions of fear, hate, jealousy, shame, despair; and foreign proteins, as in intestinal stasis. These conditions present every-day problems and demand but little discussion. Since the lesions of these various driving causes are the same; since infection, emotion, and overwork produce identical end-effects; since usually two or three of these operate simultaneously, and since the emotional states are most amenable to control, it becomes obvious why these conditions have often been controlled by means which have apparently no direct therapeutic value, such as faith in the physician, travel, diversion, prayer, healing springs, philosophy, Christian Science. Again and again, in the domain of regular medicine as in the domain of irregular medicine, the exclusion of worry has relieved the drive sufficiently to allow the body processes to overcome the primary disease. But the reverse is true also. Innumerable men, under the

strain of a chronic drive, are pushed beyond the narrow limits of safety by the added drive of grief, worry, or shame. Is it not possible that when it is understood that the various kinetic stimuli have interchangeable physical values, the game of health will be more skilfully played? Incidentally, the chronic drive presumes a mild chronic acidosis at least. This, as Lawrence Henderson suggests, might be in part counteracted by alkalies and water.

VI. KINETIC DISEASES

Passing now to that group of individuals whose organs have become effected by excessive energy transformation, we meet with our greatest difficulties. The proper prosecution of this theme would mean an extensive work on medicine. I shall, therefore, give but a few illustrations.

Graves' Disease.—First of all, perhaps the most typical of the kinetic diseases is Graves' disease. In Graves' disease the kinetic system is driven by a continuous activation, because in this disease there has been established a pathologic interaction between the brain and the thyroid, whereby the threshold to all stimuli is kept continuously low. Graves' disease exhibits a progressive alteration in every function of the body, leading eventually to exhaustion, with visible lesions, depending upon the duration and severity of the disease, in every organ and tissue of the body; not alone in the brain, adrenals, and liver, but in the heart and blood-vessels, the muscles, the thyroid, the thymus, the pancreas, the spleen, the lymphatics, the skin, the skeletal muscles, the teeth, the hair, and the bony skeleton. Extreme and protracted exhaustion from excessive exertion, excessive emotion, or chronic infection causes similar lesions.

In other words, the principal phenomena of Graves' disease are identical with the leading phenomena of any other

kinetic drive of a corresponding degree of intensity, and may be duplicated by fear, anger, sexual excitation, physical exertion, overwork, or acute infection. Conversely, many of these activations cause hyperplasia of the thyroid. Thus fear, anger, or sexual emotion may cause temporary enlargement of the thyroid; there is hyperplasia in pregnancy, in chronic infections, and perhaps in intestinal auto-intoxication as well.

There is a fundamental resemblance between certain aspects of Graves' disease, of iodism, of adreninemia, of emotion, and of infection. The resemblance so often noted between Graves' disease and excessive emotion is not surprising in view of the frequency with which the disease is traced to an emotional origin, for among the stimuli initiating Graves' disease protracted emotion is, perhaps, the most dominant. In a majority of cases careful inquiry will disclose some deeply entrenched disturbing emotional factor—a great grief, the existence of harassing home conditions, poverty or shame, business reverses, overwhelming responsibilities, an unhappy love affair or some acutely distressing thought, which drives the kinetic system incessantly. In my own experience, in cases of Graves' disease for the causation of which no factor in the external environment can be held responsible, the internal environment has usually supplied the disturbing factor—infection or auto-intoxication, for example. I have never known a case of Graves' disease to result from hard physical labor, unattended by "psychic" strain, nor from energy voluntarily and naturally expended.

Whatever the exciting cause of Graves' disease, however, whether unusual business worry, disappointment in love, a tragedy, a strong fear, the illness of a loved one, intestinal auto-intoxication, an acute or chronic infection, or the administration of excessive doses of iodin or thyroid extract,

the symptoms are identical, and closely resemble the phenomena of one of the great primitive emotions, of infection or of extreme exertion (Fig. 20).

There is a period of excessive kinetic drive in fever which exactly corresponds to the kinetic drive in emotion, and

A B

FIG. 20.—SIMILARITY BETWEEN THE FACIES OF ACUTE AND OF CHRONIC EMOTIONAL ACTIVATION.

A, Chronic emotional activation (photograph of a typical case of exophthalmic goiter); B, acute emotional activation (photograph of a soldier).

which signifies the preparation of the organism for self-defense by chemical activity, just as emotion signifies the preparation of the organism for self-defense by motor activity. The evolution of a receptor mechanism for foreign proteins may be explained on the ground that only by oxidation is the body able to split up and eliminate foreign proteins. The

one method of inducing oxidation is through the kinetic system. The living protein molecules of the body are more resistant than the foreign protein molecules, hence the body is purified by fire—by oxidation.

It would seem, therefore, that fever is the result of a driving of the kinetic mechanism by an infection (foreign protein) stimulus for purposes of self-defense by the splitting up of the molecules of the foreign protein through the transformation of latent energy into heat; and it would seem that emotion is the result of a driving of the same mechanism by a psychic stimulus for purposes of self-defense or procreation, in part, at least, by muscular action; while Graves' disease is a purposeless driving of the mechanism by some obscure disarrangement connected with a pathologic alteration in the function of the thyroid.

Reasoning from the secure facts of the clinic and the less secure data of the laboratory, I conclude that the primary lesion of exophthalmic goiter is the establishment of an abnormal facility for the passage of action currents in the central nervous system. As previously stated, Osterhaut has given us definite data as to the effect of iodin on the electric permeability of kelp. There is evidence on a vast scale that such a state of increased electric permeability exists in exophthalmic goiter. It has been stated that electric currents are increased in the skin of patients with exophthalmic goiter. Exophthalmic patients are extremely sensitive to all stimuli, infection, auto-intoxication, injury, emotion, electricity.

That these several activations involve the same mechanism is borne out by many points of similarity between Graves' disease and infections (Fig. 22). The likeness of the phenomena of the kinetic drive in Graves' disease to those of chronic infections, particularly of tuberculosis, is so marked

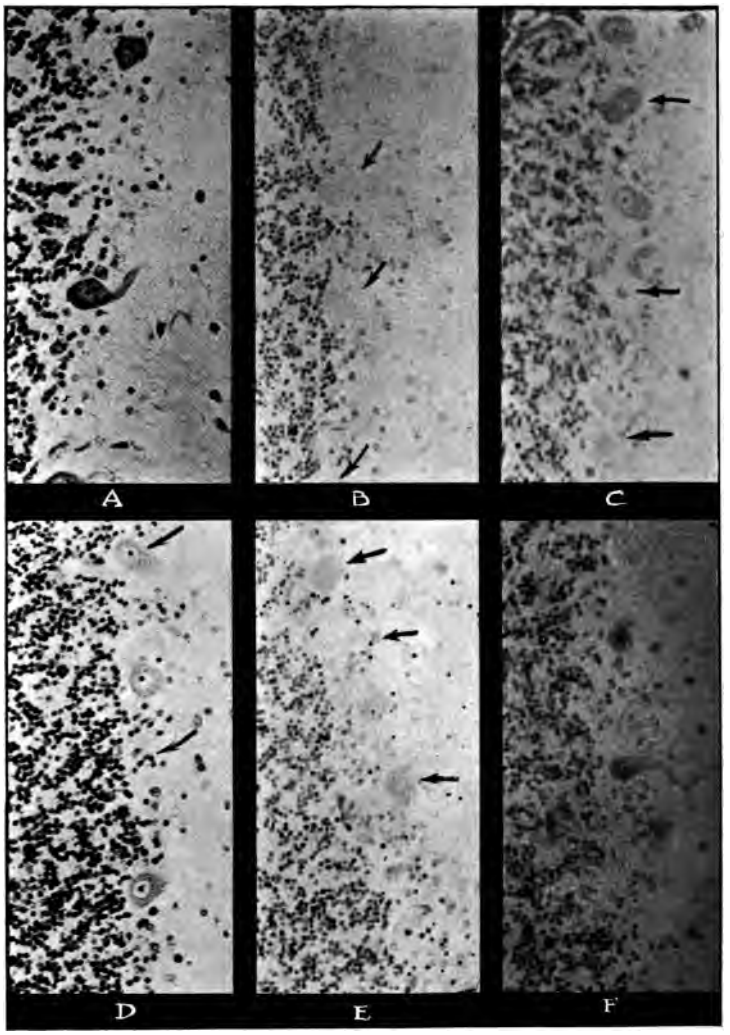


FIG. 21.—EFFECTS OF VARIOUS FORMS OF CHRONIC ACTIVATION ON THE BRAIN-CELLS. (From photomicrographs × 310.)

A, Section of normal human cerebellum (after accidental death); B, section of human cerebellum after death from acute acidosis; C, section of human cerebellum after death from exophthalmic goiter; D, section of human cerebellum after death from acute septicemia; E, section of human cerebellum after death from eclampsia; F, section of human cerebellum after death from cardiovascular disease. The arrows mark the site of the almost completely disintegrated Purkinje cells.

that it is not at all uncommon to find diagnosticians of wide experience recommending treatment for tuberculosis to a patient with Graves' disease, and an operation for Graves' disease to a patient with tuberculosis. In two different cases of the same degree of intensity it may be almost impossible to distinguish the case of Graves' disease from the case of tuberculosis. Sometimes both conditions may be present in the same patient. The following symptoms are common to both Graves' disease and tuberculosis—tachycardia, increased respiration, flushed face, tremors, persistent slight fever, nervousness, rapid loss of weight, digestive disturbances, increased acidity of the urine, hyperplasia of the thyroid and of the lymph-glands, and enlargement of the heart. Even at autopsy the lesions—barring the tuberculosis focus itself—may be so nearly identical in the two cases as to baffle differentiation. In tuberculosis as in Graves' disease the entire kinetic system is overdriven.

Thus, the kinetic theory of Graves' disease, of infections, and of emotion supplies a possible biologic interpretation of the induction of these states, of their mutual resemblance, and of the method of their control. All are modified by rest; all are temporarily controllable by morphin; all cause increased H-ion concentration in the blood; and therefore tax heavily the organs of acid neutralization, namely, the respiratory center, the kidneys, the adrenals, and the liver. *The increased respiratory rate in each of these conditions is accounted for by the specific stimulative effect of the increased H-ion concentration of the blood on the respiratory center.* The demand for neutralization of the increased acidity incident to emotion, work, infection, or Graves' disease is responded to by increased activity of the liver. If the acidity is increased so rapidly that neutralization cannot keep pace with it, then nephritis may develop as an effect of the acid

by-products upon the kidneys. Hence, in intense emotion, exertion, infections, and Graves' disease, albumin and casts are frequently and sugar sometimes found in the urine, and in extreme cases acute acidosis may develop. The acidosis of emotion, of infection, and of Graves' disease is expressed in each case by thirst. The cycles of vomiting in Graves' disease are probably caused by acidosis, which is the most common cause of death in this disease. Thus, in the immediate symptoms and in the end-effects, even to the resulting acidosis and pathologic lesions, we find a close resemblance in the essential phenomena of exertion, emotion, infection, and Graves' disease—phenomena which are harmonized and interpreted by the kinetic theory.

Cardiovascular Disease.—The analogy between diseases of the thyroid and diseases which among other organs involve the adrenals is borne out by many clinical points. Graves' disease and cardiovascular disease have many points in common. Each of these conditions bears an intimate relation to foreign protein activation and to "nervous strain." The etiology of Graves' disease is much the same as that of cardiovascular disease. In each of these diseases a recall of the unhappy circumstances or conditions which led to or precipitated the acute stage is sufficient to cause an exacerbation of all its symptoms. The most efficient means by which each of these diseases may be modified are rest, diversion, change of scene, and occupation. In each the secretion of the gland most involved seems to bear a specific relation to the production of the disease. For instance, as has been stated, the cardinal symptoms of Graves' disease may be produced in a normal person by the administration of sufficient thyroid extract, and in the patient with Graves' disease the administration of thyroid extract, even in small quantities, causes an immediate exacerbation of the symptoms. In like manner,

adrenin aggravates the symptoms of cardiovascular disease, and when given to a normal animal in excessive dosage is said to produce lesions similar to arteriosclerosis. Like results cannot be obtained by the administration of the secretion of any other gland in the body. In Graves' disease the thyroid is always enlarged; in cardiovascular disease the adrenals are usually enlarged.

The literature of the etiology of arteriosclerosis is a long record of superlative stimulations and deep depressions; a story of great risks taken and great losses borne; of heavy burdens carried and long strains endured; of vast responsibilities assumed; of excessive dissipation; of chronic infection; of auto-intoxication; of overindulgence in food and intoxicants; of great joys and great griefs; of hopes, anxieties, and despair. It is essentially a story of the modern world; of power and progress and success; of liberty and luxury and of their antitheses; of mental tolerance combined with bitter, crushing oppression. The contemplative scholar of the Middle Ages, the bucolic Swede, the wandering Scotch bard, the Italian peasant, these probably did not know arteriosclerosis except as the logical accompaniment of a ripe old age. The director of vast financial enterprises, the man who holds the fates of thousands in his hand, he who carries tremendous physical burdens; the Chinese coolie, the Japanese rickshaw man, the athlete of the western world, the emotional American, the excitable Jew, the bank president, the *bon vivant*, these are the men whose days are shortened by early hardening of the arteries, who preëmpt to themselves the cardiovascular and likewise the cardiorenal diseases. The superlatively emotional Jew, besides being a frequent victim of cardiovascular disease, is likewise a frequent sufferer from the allied condition, endarteritis obliterans. Among animals the high-spirited wild animals in cap-

tivity, the mettled race horse, and the dray horse, fretted and driven often beyond its capacity, are frequent sufferers from cardiovascular disease. The somnolent, unfettered cow is exempt.

Bright's Disease.—In the great strain laid upon the organs of reduction and elimination by the excessive causation of acid by-products as a result of the kinetic drive of emotional activation, physical exertion, and infection we may find common causes of Bright's disease. We have shown by experiment that in frightened rabbits, enraged cats, and traumatized dogs the kinetic system can be driven at such a rate of speed that the organism is unequal to the task of neutralizing the too-rapidly formed acid by-products so that they can be eliminated without injury to the kidneys. In addition, we have shown that when the activity of the brain has been depressed by morphin the rate of transformation of energy is decreased and the production of acid by-products correspondingly lessened. If, as seems probable, the adrenals and the liver are the most important agents by which the reduction of the acid by-products is accomplished, then an habitual failure of these organs to perform this function might lead to an accumulation of harmful compounds which would directly facilitate tissue degeneration in the kidneys, thus causing nephritis. In Bright's disease hyperplasia of the adrenals is frequently seen.

Diabetes.—The more powerful excitants of the kinetic system cause an increased output of adrenin, and adrenin causes the mobilization of the glycogen stored in the liver, so that, among other results of kinetic activation, glycosuria is produced. While glycosuria is not diabetes, it represents a step toward this disease, and one would expect, therefore, that the kinetic drive, which in one individual causes the breakdown of the thyroid, in another of the brain, and in

another of the adrenals, in others might produce diabetes. That this is so is shown by the fact that diabetes is improved by the conditions which obviate psychic strain. The identification of the common causes of diabetes with the common causes of Graves' disease, arteriosclerosis, neurasthenia, and Bright's disease may explain why, in the words of a certain phrase maker, "when stocks go down in New York, diabetes goes up"; why diabetes is more commonly found in large cities, among individuals and races who are constantly under a strain of business perplexities, and are constantly within sight and hearing of thousands of irritating and harassing episodes; and why it is rare in localities where leisurely and quiet ways of life prevail. In the fact that here, again, the emotional trade-driven Jew is a frequent sufferer we have important matter for consideration.

Diabetes not only numbers among its common causes the common causes of other kinetic diseases, but, as in the case of Graves' disease, arteriosclerosis, neurasthenia, etc., it is improved by rest, diversion, and dietetic control.

VII. SURGICAL METHODS OF CONTROLLING THE KINETIC DRIVE

It would seem to follow that a chronic disease which is made worse by increasing the kinetic drive would be improved by lessening the drive, and, in like manner, would be improved temporarily by blocking the drive by means of morphin. Morphin is but a temporary expedient, however, and the results of its use may be worse than the disease caused by the drive. If the effects of morphin are produced by its control of the driving force of the brain, thus preventing the brain from driving the adrenals and the thyroid, then a like result to that produced by morphin could be secured by breaking the connection between the brain and the thyroid and the

adrenals; by the excision of a portion of the thyroid and of the adrenals; and, if still further blocking of brain impulses be required, by dividing the cervical sympathetics as well.

One would not expect these procedures to produce any subjective change in the patient. No function would be lost. He could work, be subject to emotion, and respond to infection as before, with the following exceptions—his power of physical exertion would be diminished, as would his response to emotional stimuli or to infection. His acid excretion would diminish and his sugar tolerance would increase. In short, those diseases that are *temporarily* improved by morphin should be *permanently* improved by this process of *dekineticization.*

On this conception I have ventured on new surgical ground, and have performed fourteen operations on patients with chronic diseases resulting from an excessive kinetic drive. I first operated on eleven hopeless epileptics, then on three cases of Raynaud's disease, and finally on an advanced diabetic. All made good operative recoveries. The operation performed in different stages comprised the excision of one adrenal, the excision of approximately three-fourths of the thyroid, and the division of the cervical sympathetic trunks.

It is now two and a half years since the first of these operations was performed. It was not expected that epilepsy would be cured, but that the force of the attacks would be diminished and perhaps the intervals lengthened, for, since the epileptic attack represents a powerful temporary kinetic drive, it seemed possible that the severity of that drive might be modified. No case has been cured, but all made good operative recoveries, and the severity of the attacks and the length of the intervals have been favorably influenced. The fact that some of these cases showed an

increased sugar tolerance confirmed us in our belief that the same procedure might be of avail in cases of diabetes. The principal net result of these operations on epileptic patients was the assurance that in man as in animals these procedures do not interfere with normal functions. This fact being established, other fields are now being approached cautiously.

In Raynaud's disease there is a striking diversion of blood to the extremities—in ebbs and flows. These rhythms are in a measure determined by emotion, by cold, etc. Since it is known that Raynaud's disease is most common in that emotional race, the Hebrew; that the most significant effect of emotion is the increased mobilization of adrenin, and that one of the results of the increased fabrication of adrenin is the transference of blood from the inner organs to the surface of the body, it would seem that this otherwise hopeless disease might with propriety be attacked on a kinetic basis. The three cases thus surgically treated by me—the first two and a half years ago—give fair promise of recovery. But in a disease of such chronicity, the different phases of which are manifested in such long rhythms, judgment must be reserved until a long time has elapsed and until many cases have been observed.

Since the kinetic drive may be concerned in greater or less degree in the causation or continuance of Raynaud's disease, Graves' disease, Bright's disease, and diabetes, on *à priori* grounds, it is evident that either none or all of these will be benefited by a surgical reduction of the driving power of the kinetic system.

We have already compared the effects of the kinetic drive upon the normal human mechanism to the normal action of a locomotive. In like manner the problem presented by these kinetic diseases may be compared to the effect upon a

damaged automobile of reckless driving by an irresponsible chaffeur. In such a case the machine may be prematurely wrecked, whereas, with careful driving at a moderate speed, even the damaged automobile may give long service. Vast numbers of men and women today possess such damaged mechanisms which the stress of present-day life is driving to inevitable destruction. Included in this doomed throng are many of the most useful men and women, the very kinetic temperament to which they owe their achievements proving to be also their greatest menace. It is for such cases as these, in which medicine fails to provide the necessary kinetic control, that this surgical procedure is proposed. In considering this operation it must be borne in mind that we are dealing with poor surgical risks and, as far as the adrenalectomy is concerned, a technically difficult operation. Every possible protection, therefore, should be provided. It is most important that the operation be performed under nitrous-oxid-oxygen, rather than under the lipoid solvent—ether. The principle of anociation should be applied throughout the operation, as the excessive acid products resulting from cutting or handling sensitive tissues may diminish too much the narrow margin of safety and dispatch the patient. Especially is this true of diabetes.

The value of surgical modification of the kinetic system in that intense kinetic drive—Graves' disease—is established. We know that by dividing the nerve-supply of the thyroid, ligating the thyroid arteries, or excising a portion of the thyroid gland, this disease is modified or cured. In these cases the blood-pressure falls, the myocarditis improves, albumin and casts disappear, the sugar tolerance is raised, the intense neurasthenia is improved. In other words, the renal, cardiovascular, glycogenetic, and psychic phenomena simultaneously improve. I have no doubt that the excision

of an adrenal or the division of the nerve-supply to the adrenals in Graves' disease would also facilitate the cure.

We have referred to the lessening of glycosuria by operation in certain cases of Graves' disease. It is well known that in cases of either adrenal or thyroid deficiency sugar tolerance is raised, while, on the contrary, the injection of excessive amounts of adrenin or of excessive thyroid extract mobilizes sugar. Therefore, in intractable diabetes may it not be possible that the diminution of the total mass of the adrenals and of the thyroid may sufficiently increase the sugar tolerance to mitigate or actually to cure the disease? The case of diabetes which I have so treated, through the courtesy of Dr. C. F. Hoover and Dr. C. D. Christie of Lakeside Hospital, is a male, forty-two years of age, who was admitted to Lakeside Hospital in January, 1915. For a period of six months, until June 25th, when the first operation was performed, the amount of sugar in his urine had ranged daily from 9.5 to 202.5 grams, with an average of 96.4 grams. At no time during these six months until the morning of the first operation was he known to be sugar free. In June, at intervals of three and seventeen days respectively, the following operations were performed: (1) Section of the right cervical sympathetic, (2) left adrenalectomy, and (3) excision of the left cervical sympathetic with partial thyroidectomy. The patient made a good operative recovery. On the day of the first operation the sugar content of the urine was 83.6 grams; on the following day it was 8.4 grams, since which time, with the exception of a few instances one day between the last two operations, he has been continuously sugar free. This patient now, four months after his first operation, is taking approximately 250 grams of carbohydrates daily, and since his operation he has gained 9 pounds. It should be stated that Dr.

Christie has continued a careful medical supervision of the case, employing the Allen treatment. Therefore, to obtain the surgical net result we must subtract from this striking improvement the undetermined factor of the Allen treatment.

VIII. SUMMARY

The *kinetic theory* harmonizes many facts in the great clinic of life as well as in the restricted clinics of medicine; it emphasizes the value of a mechanistic view of life in the study of both normal and pathologic processes; and it suggests a philosophy of life by means of which self-preservation may be secured through kinetic control.

According to the kinetic theory, the resemblance of many normal and pathologic processes—exertion, emotion, infection, auto-intoxication, etc.—suggests that the mechanism by which they are produced is identical with the mechanism by which the transformation of energy and the elimination of acid by-products are accomplished; that is, that these conditions are caused by variations in the *kinetic drive.*

Since an excessive *kinetic drive* may be the result of the simultaneous action of various factors in the external and the internal environment, then the control of one or more of these factors will lessen the drive and mitigate its effect. Thus the substitution of hope for fear may relieve the organism of one driving factor and by so much relieve the strain upon the kinetic system. In other cases the depression of the activity of the brain by morphin or by nitrous oxid anesthesia controls an acute kinetic drive.

For still other cases in which disease has resulted from the physical injury wrought in certain organs by an excessive drive, *it is proposed as a problem, not as an accomplished fact,* that the activating organs of the kinetic system, the adrenals and the thyroid, be reduced in size and that their com-

munication with the driving organ—the brain—be in part severed. By an analogous method the result of an intense kinetic drive—Graves' disease—is modified or cured; the accompanying cardiovascular, cardiorenal, myocardial, and neurasthenic symptoms are coincidentally relieved, and sugar tolerance is raised.

If Graves' disease, which is due directly to the overspeeding of the kinetic system, is thus relieved by partial excision of one of the driving organs, the thyroid, this mechanistic treatment effecting simultaneously the cure of the conditions brought about by the driving power of Graves' disease itself, then the logical conclusion is that these allied diseases when brought into existence by other kinetic drives may be mitigated or cured by a *dekineticizing* operation.

This is suggested as an *unsolved problem* suggested by a large amount of experimental data.